U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-261 774

James Lake
Kosciusko County, Indiana

National Eutrophication Survey, Corvallis, OR

Prepared For
Corvallis Environmental Research Lab., OR

July 1976

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.

4. TITLE AND SUBTITLE
Report on James Lake, Kosciusko County, Indianana

5. REPORT DATE
Prepared July 1976

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)
Anonymous (National Eutrophication Survey Staff)

8. PERFORMING ORGANIZATION REPORT NO.
Working Paper # 330

9. PERFORMING ORGANIZATION NAME AND ADDRESS
National Eutrophication Survey
U.S. Environmental Protection Agency
200 S. W. 35th St.
Corvallis, Oregon 97330

10. PROGRAM ELEMENT NO.

11. CONTRACT/GRANT NO.

12. SPONSORING AGENCY NAME AND ADDRESS
Office of Research and Development
U.S. Environmental Protection Agency
401 M Street, S. W.
Washington, DC 20460

13. TYPE OF REPORT AND PERIOD COVERED
Final - 1973

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		05B 05C

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release unlimited		33
	20. SECURITY CLASS *(This page)*	22. PRICE
		4.00

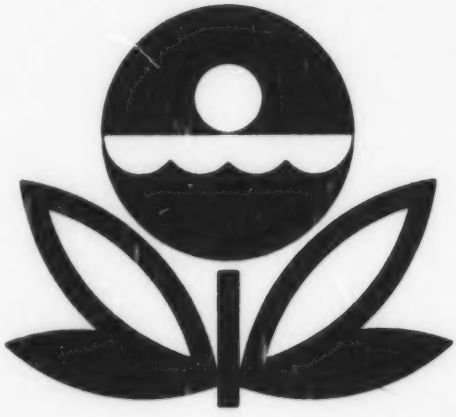
EPA Form 2220-1 (9-73)

010014

PB 261 774

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES



CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

P.O. 699-440

REPORT
ON
JAMES LAKE
KOSCIUSKO COUNTY
INDIANA
EPA REGION V
WORKING PAPER No. 330

WITH THE COOPERATION OF THE
INDIANA STATE BOARD OF HEALTH
AND THE
INDIANA NATIONAL GUARD
JULY, 1976

ia1

CONTENTS

	Page
Foreword	ii
List of Indiana Study Lakes	iv
Lake and Drainage Area Map	v
Sections	
I. Conclusions	1
II. Lake and Drainage Basin Characteristics	4
III. Lake Water Quality Summary	5
IV. Nutrient Loadings	9
V. Literature Reviewed	13
VI. Appendices	14

FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning {§303(e)}, water quality criteria/standards review {§303(c)}, clean lakes {§314(a,b)}, and water quality monitoring {§106 and §305(b)} activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Indiana State Board of Health for professional involvement, to the Indiana National Guard for conducting the tributary sampling phase of the Survey, and to those Indiana wastewater treatment plant operators who provided effluent samples and flow data.

The staff of the Division of Water Pollution Control, Indiana State Board of Health, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

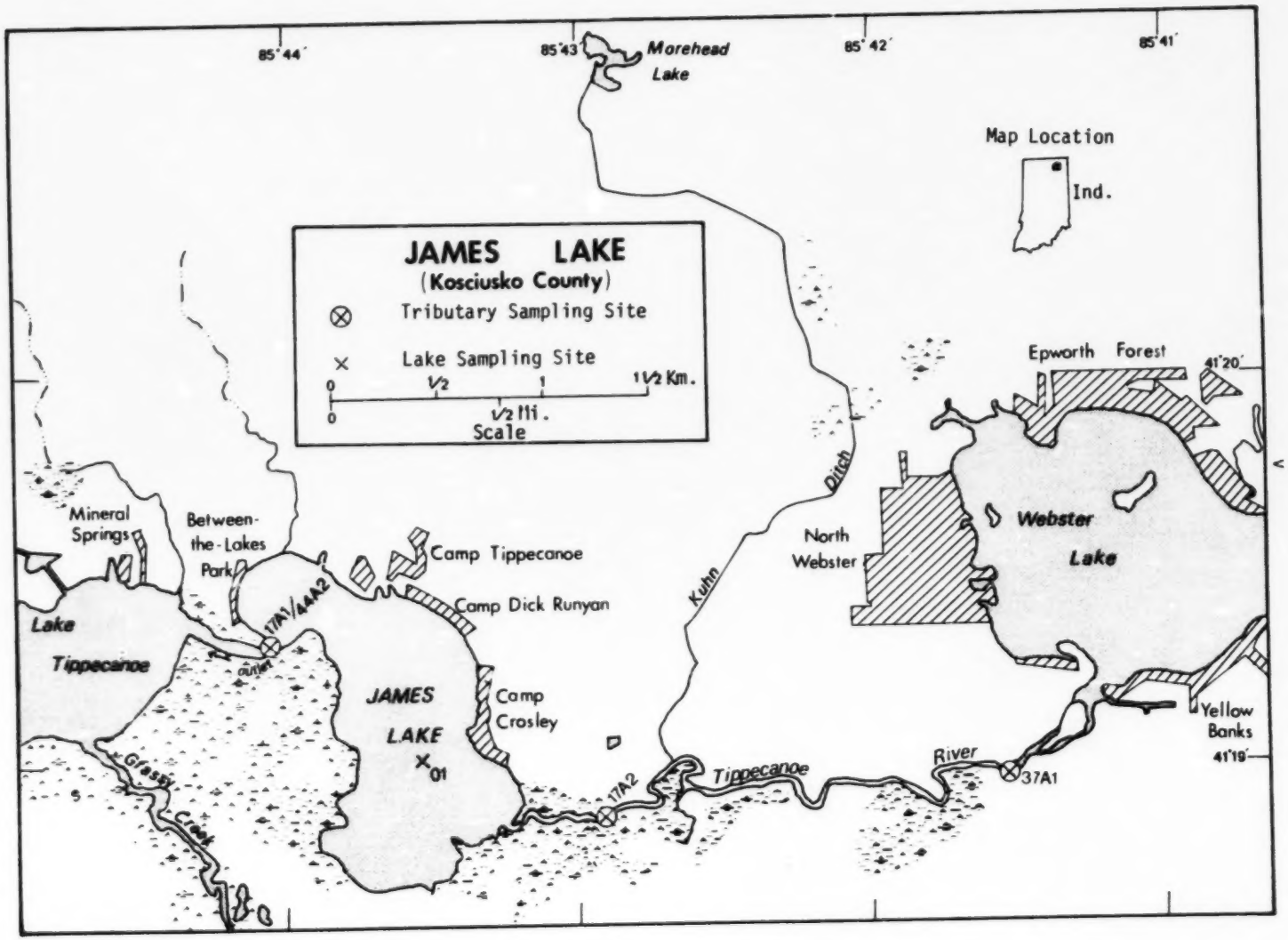
Major General Alfred F. Ahner, Adjutant General of Indiana, and Project Officers Lt. Colonel Charles B. Roberts (Retired) and Colonel Robert L. Sharp, who directed the volunteer efforts of the Indiana National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF INDIANA

LAKE NAME	COUNTY
Bass	Starke
Cataract	Owen, Putnam
Crooked	Steuben
Dallas	LaGrange
Geist	Hamilton, Marion
Hamilton	Steuben
Hovey	Posey
James	Kosciusko
James	Steuben
Long	Steuben
Marsh	Steuben
Mississinewa	Grant, Miami, Wabash
Maxinkuckee	Marshall
Monroe	Brown, Monroe
Morse	Hamilton
Olin	LaGrange
Oliver	LaGrange
Pigeon	Steuben
Sylvan	Noble
Tippecanoe	Kosciusko
Versailles	Ripley
Wawassee	Kosciusko
Webster	Kosciusko
Westler	LaGrange
Whitewater	Union
Winona	Kosciusko
Witmer	LaGrange


85°44'
85°43'
85°42'
85°41'
Morehead Lake
Map Location
Ind.
JAMES LAKE
(Kosciusko County)
Tributary Sampling Site
Lake Sampling Site
0 1/2 1 1 1/2 Km.
0 1/2 Mi.
Scale
Epworth Forest
41°20'
Mineral Springs
Between-the-Lakes Park
Camp Tippecanoe
Camp Dick Runyan
17A1/44A2
outlet
Lake Tippecanoe
JAMES LAKE
X01
Camp Crosley
Grassy Creek
17A2
Tippecanoe River
37A1
Kuhn Ditch
North Webster
Webster Lake
Yellow Banks
41°19'

JAMES LAKE

STORET NO. 1817

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that James Lake is eutrophic. It ranked eleventh in overall trophic condition when the 27 Indiana lakes sampled in 1973 were compared using a combination of six parameters*. Seven of the lakes had less median total phosphorus, nine had less median dissolved phosphorus, 15 had less median inorganic nitrogen, 13 had less mean chlorophyll a, and 11 had greater mean Secchi disc transparency. Hypolimnetic dissolved oxygen was depleted in August and October.

Survey limnologists noted macrophytes along the shorelines in August and October.

B. Rate-Limiting Nutrient:

The algal assay results indicate that James Lake was phosphorus limited at the time the sample was collected (05/03/73).

The lake data indicate phosphorus limitation at all sampling times.

C. Nutrient Controllability:

1. Point sources--During the sampling year, James Lake received a total phosphorus loading just in excess of that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a

* See Appendix A.

eutrophic loading (see page 12). It is estimated that lakeshore septic tanks contributed less than 1% of that load, but a shoreline survey would be necessary to determine the significance of those sources.

Following termination of the Survey sampling, personnel of the Kosciusko County Health Department reported to the Indiana Stream Pollution Control Agency the existence of two outfalls discharging municipal wastes to the Tippecanoe River below the Webster Lake dam (BonHomme, 1976). At the time of preparation of this report, the nutrient significance of these discharges was not known. However, the nutrient contributions of these sources were included in the loads measured at station 17 A-2 during the sampling year (see map, page v).

Sewage treatment facilities are planned for the Town of North Webster which also will treat wastes from the community on the northeast corner of Webster Lake*, including the wastes from the Epworth Forest Church Camp (BonHomme, op. cit.). The collection system will intercept the outfalls noted above. The effluent of the new plant will be discharged to the Tippecanoe River upstream from James Lake.

When completed, the treatment facilities will reduce the indirect point-source load presently reaching James Lake via the Webster Lake outlet and will eliminate the two discharges noted above. However,

* Working Paper No. 345.

the treatment plant will contribute an unknown amount of nutrients to James Lake via the Tippecanoe River, and it will be necessary to evaluate the significance of this new phosphorus source once the plant is put in operation.

There was an apparent loss of phosphorus from the lake during the sampling year. This may have been due to unknown and unmeasured point sources discharging directly to the lake, insufficient sampling, underestimation of the phosphorus load from septic tanks, or actual phosphorus wash-out following the Indiana phosphate detergent ban which became effective in January, 1972.

2. Non-point sources--The phosphorus exports of non-point sources apparently accounted for over 99% of the phosphorus reaching the lake during the sampling year. The Tippecanoe River contributed over 90% of the total at a rate of 10 $kg/km^2/yr$. This rate is relatively low and compares well to the rates of other streams in the area.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 1.14 kilometers^2.
2. Mean depth: 8.2 meters.
3. Maximum depth: 19.2 meters.
4. Volume: 9.348×10^6 m^3.
5. Mean hydraulic retention time: 80 days.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Tippecanoe River	137.0	1.30
Minor tributaries & immediate drainage -	6.7	0.06
Totals	143.7	1.36

2. Outlet -

Tippecanoe River	144.8**	1.36

C. Precipitation***:

1. Year of sampling: 79.7 centimeters.
2. Mean annual: 88.5 centimeters.

---

† Table of metric conversions--Appendix B.
†† Winters, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

James Lake was sampled three times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at one station on the lake (see map, page v). During each visit, a single depth-integrated (4.6 m to surface) sample was collected for phytoplankton identification and enumeration; and a similar sample was taken for chlorophyll a analysis. During the first visit, a single 18.9-liter depth-integrated sample was collected for algal assays. The maximum depth sampled was 16.8 meters.

The sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR JAMES LAKE
STORET CODE 1817

PARAMETER	1ST SAMPLING (5/ 3/73) 1 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (8/ 4/73) 1 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (10/13/73) 1 SITES RANGE	MEAN	MEDIAN
TEMP (C)	9.3 - 13.7	12.1	13.6	9.6 - 24.8	14.8	22.6	10.8 - 19.8	15.5	15.8
DISS OXY (MG/L)	7.0 - 9.4	8.3	8.5	0.0 - 8.3	2.8	1.5	0.0 - 8.4	2.6	0.0
CNDCTVY (MCHOMO)	500. - 520.	504.	500.	358. - 434.	406.	424.	365. - 388.	377.	382.
PH (STAND UNITS)	8.0 - 8.3	8.2	8.2	7.4 - 8.4	7.9	7.8	7.4 - 8.4	7.8	7.6
TOT ALK (MG/L)	200. - 202.	200.	200.	172. - 220.	189.	178.	166. - 232.	193.	193.
TOT P (MG/L)	0.022 - 0.033	0.025	0.023	0.015 - 0.081	0.031	0.019	0.022 - 0.179	0.062	0.030
ORTHO P (MG/L)	0.002 - 0.006	0.003	0.002	0.003 - 0.062	0.018	0.004	0.008 - 0.099	0.037	0.015
NO2+NO3 (MG/L)	0.980 - 1.000	0.994	1.000	0.050 - 0.860	0.260	0.140	0.030 - 0.060	0.047	0.050
AMMONIA (MG/L)	0.050 - 0.210	0.100	0.060	0.050 - 0.990	0.252	0.070	0.040 - 2.220	0.846	0.410
KJEL N (MG/L)	0.800 - 1.000	0.860	0.800	0.700 - 1.600	0.940	0.800	0.800 - 3.600	1.843	1.300
INORG N (MG/L)	1.030 - 1.210	1.094	1.060	0.100 - 1.130	0.512	0.260	0.070 - 2.280	0.893	0.470
TOTAL N (MG/L)	1.780 - 2.000	1.854	1.800	0.850 - 1.740	1.200	0.990	0.840 - 3.660	1.890	1.360
CHLRPYL A (UG/L)	5.8 - 5.8	5.8	5.8	11.7 - 11.7	11.7	11.7	17.1 - 17.1	17.1	17.1
SECCHI (METERS)	1.5 - 1.5	1.5	1.5	****** -**********			1.8 - 1.8	1.8	1.8

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
05/03/73	1. Flagellates	3,434
	2. *Asterionella sp.*	753
	3. *Dinobryon sp.*	663
	4. *Chroococcus sp.*	301
	5. *Synedra sp.*	211
	Other genera	662
	Total	6,024
08/04/73	1. *Aphanizomenon sp.*	685
	2. *Microcystis sp.*	597
	3. *Scenedesmus sp.*	544
	4. *Cyclotella sp.*	457
	5. *Lyngbya sp.*	334
	Other genera	1,702
	Total	4,319
10/13/73	1. Flagellates	984
	2. *Lyngbya sp.*	414
	3. *Dinobryon sp.*	259
	4. *Oscillatoria sp.*	155
	5. *Melosira sp.*	121
	Other genera	604
	Total	2,537

2. Chlorophyll *a* -

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
05/03/73	1	5.8
08/04/73	1	11.7
10/13/73	1	17.1

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	<0.005	1.108	0.1
0.050 P	0.055	1.108	11.1
0.050 P + 1.0 N	0.055	2.108	13.1
1.0 N	<0.005	2.108	0.1

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of James Lake was low at the time the sample was collected. There was a significant increase in yield when the level of orthophosphorus was increased, but there was no change in yield when nitrogen alone was added. Based on these results, phosphorus limitation is indicated.

The lake data also indicate phosphorus limitation; i.e., the mean inorganic nitrogen/orthophosphorus ratios were 24/1 or greater at all sampling times, and phosphorus limitation would be expected.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Indiana National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff month of March when two samples were collected. Sampling was begun in June, 1973, and was completed in May, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Indiana District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the nutrient loads at station A-2 of nearby Webster Lake**, in $kg/km^2/year$, and multiplying by the ZZ area of James Lake in km^2.

Note that the estimated phosphorus load from septic tanks was reduced by 50% to adjust for the phosphate detergent ban in effect in Indiana since January, 1972.

---

* See Working Paper No. 175.
** Working Paper No. 345.

A. Waste Sources:

1. Municipal - Unknown

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (non-point load) -		
Tippecanoe River	1,345	90.6
b. Minor tributaries & immediate drainage (non-point load) -	115	7.7
c. Municipal - Unknown	?	-
d. Septic tanks* -	5	0.3
e. Known industrial - None	-	-
f. Direct precipitation** -	20	1.4
Total	1,485	100.0

2. Outputs -

Lake outlet - Tippecanoe River 1,535

3. Net annual P loss - 50 kg.

* Estimate based on three lakeshore camps and one park; see Working Paper No. 175.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Tippecanoe River	93,620	92.3
b. Minor tributaries & immediate drainage (non-point load) -	6,285	6.2
c. Municipal - Unknown	?	-
d. Septic tanks* -	250	0.3
e. Known industrial - None	-	-
f. Direct precipitation** -	1,230	1.2
Total	101,385	100.0

2. Outputs -

Lake outlet - Tippecanoe River 97,490

3. Net annual N accumulation - 3,895 kg.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Tippecanoe River	10	683

* Estimate based on three lakeshore camps and one park; see Working Paper No. 175.
** See Working Paper No. 175.

E. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	1.30	loss*	88.8	3.2

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of James Lake:	
"Dangerous" (eutrophic loading)	1.16
"Permissible" (oligotrophic loading)	0.58

* See page 3.

V. LITERATURE REVIEWED

BonHomme, Harold L., 1976. Personal communication (planned waste treatment facilities at North Webster; sewage outfalls in drainage). IN Div. of Water Poll. Contr., Indianapolis.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

Winters, John, 1975. Personal communication (lake morphometry). IN Div. of Water Poll. Contr., Indianapolis.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
1805	CATAWACT LAKE	0.059	1.660	466.667	10.744	15.000	0.013
1811	GEIST RESERVOIR	0.074	1.080	472.500	45.950	11.600	0.004
1817	JAMES LAKE	0.024	1.030	434.000	11.533	15.000	0.004
1827	MISSISSINEWA RESERVOIR	0.107	2.400	473.444	15.778	15.000	0.029
1828	MONROE RESERVOIR	0.025	0.325	436.823	6.947	15.000	0.007
1829	MORSE RESERVOIR	0.084	3.325	473.222	56.167	15.000	0.009
1836	WAWASEE LAKE	0.012	0.210	364.500	5.000	14.600	0.003
1837	WEBSTER LAKE	0.025	0.790	431.000	11.500	15.000	0.005
1839	WHITEWATER LAKE	0.084	1.620	470.167	33.083	15.000	0.012
1840	WINONA LAKE	0.035	1.250	444.667	11.211	15.000	0.011
1841	WESTLEW LAKE	0.035	0.860	427.125	10.712	15.000	0.013
1842	WITMER LAKE	0.035	0.900	440.333	11.917	15.000	0.011
1843	LAKE MAXINKUCKEE	0.020	0.220	400.400	5.483	15.000	0.003
1844	TIPPECANOE LAKE	0.019	0.195	391.500	6.050	15.000	0.005
1845	DALLAS LAKE	0.029	0.830	413.333	10.067	15.000	0.014
1846	OLIN LAKE	0.012	1.460	403.333	4.867	14.900	0.003
1847	OLIVER LAKE	0.009	0.920	392.000	3.767	14.800	0.004
1848	SYLVAN LAKE	0.170	0.130	469.833	47.480	14.800	0.017
1849	HOVEY LAKE	0.062	1.050	489.333	84.267	7.600	0.024
1850	VERSAILLES LAKE	0.139	1.090	482.000	25.078	14.500	0.019
1851	BASS LAKE	0.040	0.250	471.375	29.367	7.000	0.012
1852	CROOKED LAKE	0.019	0.120	410.111	5.578	15.000	0.005
1853	LAKE JAMES	0.016	0.190	352.444	4.856	15.000	0.005
1854	LONG LAKE	0.204	1.920	442.667	16.100	15.000	0.130
1855	PIGEON LAKE	0.058	1.445	442.667	11.400	15.000	0.015
1856	MARSH LAKE	0.093	0.270	451.333	34.467	15.000	0.055
1857	HAMILTON LAKE	0.033	0.720	413.167	17.450	15.000	0.01

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
1805	CATARACT LAKE	37 (9)	15 (4)	31 (8)	62 (16)	35 (0)	37 (9)	217
1811	GEIST RESERVOIR	27 (7)	35 (9)	15 (4)	12 (3)	92 (24)	62 (16)	243
1817	JAMES LAKE	73 (19)	42 (11)	58 (15)	50 (13)	35 (0)	65 (17)	323
1827	MISSISSINEWA RESERVOIR	12 (3)	4 (1)	8 (2)	38 (10)	35 (0)	8 (2)	105
1828	MONROE RESERVOIR	67 (17)	69 (18)	54 (14)	73 (19)	35 (0)	69 (18)	367
1829	MORSE RESERVOIR	23 (6)	0 (0)	12 (3)	4 (1)	35 (0)	58 (15)	132
1836	WAWASEE LAKE	94 (24)	85 (22)	96 (25)	88 (23)	85 (22)	98 (25)	546
1837	WEBSTER LAKE	67 (17)	62 (16)	62 (16)	54 (14)	35 (0)	81 (21)	361
1839	WHITEWATER LAKE	19 (5)	19 (5)	23 (6)	19 (5)	35 (0)	42 (11)	157
1840	WINONA LAKE	50 (12)	27 (7)	38 (10)	58 (15)	35 (0)	52 (13)	260
1841	WESTLER LAKE	50 (12)	54 (14)	65 (17)	65 (17)	35 (0)	37 (9)	306
1842	WITMER LAKE	50 (12)	50 (13)	50 (13)	42 (11)	35 (0)	52 (13)	279
1843	LAKE MAXINKUCKEE	77 (20)	81 (21)	85 (22)	85 (22)	35 (0)	98 (25)	461
1844	TIPPECANOE LAKE	85 (22)	88 (23)	92 (24)	77 (20)	35 (0)	85 (22)	462
1845	DALLAS LAKE	62 (16)	58 (15)	69 (18)	69 (18)	35 (0)	31 (8)	324
1846	OLIN LAKE	94 (24)	23 (6)	81 (21)	92 (24)	73 (19)	92 (24)	455
1847	OLIVER LAKE	100 (26)	46 (12)	88 (23)	100 (26)	79 (20)	88 (23)	501
1848	SYLVAN LAKE	4 (1)	96 (25)	27 (7)	8 (2)	79 (20)	23 (6)	237
1849	HOVEY LAKE	31 (8)	38 (10)	0 (0)	0 (0)	96 (25)	12 (3)	177
1850	VERSAILLES LAKE	8 (2)	31 (8)	4 (1)	27 (7)	88 (23)	15 (4)	173
1851	BASS LAKE	42 (11)	77 (20)	19 (5)	23 (6)	100 (26)	46 (12)	307
1852	CROOKED LAKE	81 (21)	100 (26)	77 (20)	81 (21)	35 (0)	75 (19)	449
1853	LAKE JAMES	88 (23)	92 (24)	100 (26)	96 (25)	35 (0)	75 (19)	486
1854	LONG LAKE	0 (0)	12 (3)	44 (11)	35 (9)	35 (0)	0 (0)	126
1855	PIGEON LAKE	37 (9)	8 (2)	44 (11)	46 (12)	35 (0)	27 (7)	197
1856	MARSH LAKE	15 (4)	73 (19)	35 (9)	15 (4)	35 (0)	4 (1)	177
1857	HAMILTON LAKE	58 (15)	65 (17)	73 (19)	31 (8)	35 (0)	19 (5)	281

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	1836	WAWASEE LAKE	546
2	1847	OLIVER LAKE	501
3	1853	LAKE JAMES	486
4	1844	TIPPECANOE LAKE	462
5	1843	LAKE MAXINKUCKEE	461
6	1846	OLIN LAKE	455
7	1852	CROOKED LAKE	449
8	1828	MONROE RESERVOIR	367
9	1837	WEBSTER LAKE	361
10	1845	DALLAS LAKE	324
11	1817	JAMES LAKE	323
12	1851	BASS LAKE	307
13	1841	WESTLER LAKE	306
14	1857	HAMILTON LAKE	281
15	1842	WITHER LAKE	279
16	1840	WINONA LAKE	260
17	1811	GEIST RESERVOIR	243
18	1848	SYLVAN LAKE	237
19	1805	CATARACT LAKE	217
20	1855	PIGEON LAKE	197
21	1856	MARSH LAKE	177
22	1849	HOVEY LAKE	177
23	1850	VERSAILLES LAKE	173
24	1839	WHITEWATER LAKE	157
25	1829	MORSE RESERVOIR	132
26	1854	LONG LAKE	126
27	1827	MISSISSINEWA RESERVOIR	105

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR INDIANA 03/29/76

LAKE CODE 1817 JAMES LAKE AT OSWEGO

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 144.8

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1817A1	144.8	1.81	2.10	2.92	2.75	1.78	1.36	0.82	0.31	0.28	0.31	0.71	1.27	1.36
1817A2	137.0	1.73	1.98	2.78	2.61	1.70	1.27	0.79	0.31	0.27	0.31	0.68	1.22	1.30
1817ZZ	6.5	0.071	0.091	0.136	0.125	0.079	0.062	0.037	0.010	0.010	0.010	0.031	0.062	0.060

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 144.8
SUM OF SUB-DRAINAGE AREAS = 143.5
TOTAL FLOW IN = 16.38
TOTAL FLOW OUT = 16.42

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
1817A1	6	73	2.747	9	6.683				
	7	73	0.878	14	0.566				
	8	73	0.850	11	0.623				
	9	73	0.269	9	0.227				
	10	73	0.263	13	0.170				
	11	73	0.623	10	0.311	16	0.311		
	12	73	1.303	15	1.161				
	1	74	3.058	19	1.586				
	2	74	3.596	2	4.474	16	2.322		
	3	74	4.502	2	3.285	16	4.559		
	4	74	2.605	13	2.633				
	5	74	2.067	19	2.492				
1817A2	6	73	2.605	9	6.343				
	7	73	0.821	14	0.538				
	8	73	0.793	11	0.595				
	9	73	0.255	9	0.215				
	10	73	0.249	13	0.161				
	11	73	0.595	10	0.243				
	12	73	1.246	15	1.104				
	1	74	2.888	19	1.501				
	2	74	3.398	2	4.248	16	2.209		
	3	74	4.248	2	3.115	16	4.304		
	4	74	2.464	13	2.492				
	5	74	1.954	19	2.350				
1817ZZ	6	73	0.123	9	0.283				
	7	73	0.039	14	0.025				
	8	73	0.037	11	0.028				
	9	73	0.012	9	0.010				
	10	73	0.012	13	0.004				
	11	73	0.028	10	0.013	16	0.013		
	12	73	0.059	15	0.052				
	1	74	0.136	19	0.071				
	2	74	0.161	2	0.201	16	0.104		
	3	74	0.201	2	0.147	16	0.203		
	4	74	0.116	13	0.114				
	5	74	0.092	19	0.071				

APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 76/03/30

181701
41 19 02.0 085 43 36.0 3
JAMES LAKE
18085 INDIANA

051792

11EPALES 2111202
0056 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/05/03	15 15	0000	13.7		60	500	8.30	200	0.060	0.900	1.000	0.002
	15 15	0004	13.7	9.4		500	8.20	200	0.060	0.800	0.990	0.002
	15 15	0021	13.6	9.4		500	8.20	200	0.050	0.800	0.980	0.002
	15 15	0035	10.3	7.6		500	8.10	200	0.120	0.800	1.000	0.003
	15 15	0052	9.3	7.8		520	8.00	202	0.210	1.000	1.000	0.006
73/08/04	11 50	0000	24.8			434	8.40	173	0.060	0.800	0.060	0.003
	11 50	0005	23.8	8.3		424	8.30	172	0.050	0.800	0.050	0.004
	11 50	0015	22.6	3.0		427	7.80	178	0.070	0.800	0.190	0.004
	11 50	0025	13.4	0.1		386	7.40	200	0.090	0.700	0.860	0.015
	11 50	0046	9.6	0.0		358	7.40	220	0.990	1.600	0.140	0.062
73/10/13	15 20	0000	19.8		72	385	8.40	168	0.060	1.000	0.030	0.008
	15 20	0005	19.8	8.4		382	8.40	166	0.050	0.800	0.040	0.013
	15 20	0015	19.4	7.4		382	8.20	166	0.040	0.900	0.030	0.014
	15 20	0025	15.8	0.0		388	7.60	193	0.410	1.300	0.060	0.015
	15 20	0035	11.9	0.0		367	7.50	201	1.100	2.100	0.060	0.040
	15 20	0045	11.1	0.0		365	7.40	232	2.040	3.200	0.050	0.073
	15 20	0055	10.8	0.0		367	7.40	228	2.220	3.600	0.060	0.099

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/05/03	15 15	0000	0.023	5.8
	15 15	0004	0.024	
	15 15	0021	0.022	
	15 15	0035	0.023	
	15 15	0052	0.033	
73/08/04	11 50	0000	0.018	11.7
	11 50	0005	0.019	
	11 50	0015	0.020	
	11 50	0025	0.015	
	11 50	0046	0.081	
73/10/13	15 20	0000	0.022	17.1
	15 20	0005	0.027	
	15 20	0015	0.029	
	15 20	0025	0.030	
	15 20	0035	0.042	
	15 20	0045	0.103	
	15 20	0055	0.179	

STORET RETRIEVAL DATE 76/04/07

1817A1 and 1844A2
41 19 50.0 085 44 02.0 4
TIPPECANOE RIVER
18 7.5 N WEBSTER
051792
O/JAMES LAKE
BANK OFF PENINSULA IN BETWEEN THE LAKES
2111204
11EPALES
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	13	50	0.520	2.100	0.052	0.005	0.020
73/07/14	07	45	0.013	1.380	0.016	0.005K	0.020
73/08/11	11	30	0.010K	0.960	0.021	0.005K	0.015
73/09/09	13	50	0.022	1.050	0.040	0.007	0.025
73/10/13	10	40	0.011	0.900	0.028	0.005	0.030
73/11/10	12	30	0.270	1.250	0.168	0.007	0.040
73/11/16	12	54	0.034	0.950	0.231		0.026
73/12/15	09	30	0.156	0.900	0.168	0.008	0.025
74/02/02	11	00	1.260	1.100	0.060	0.010	0.060
74/02/16	10	40	1.900	1.700	0.050	0.015	0.095
74/03/02	09	05	0.460	1.900	0.230	0.015	0.055
74/03/16	09	00	1.430	3.300	0.060	0.005K	0.030
74/04/13	09	27	1.280	2.200	0.060	0.005	0.025
74/05/19	14	30	1.680	1.100	0.040	0.010	0.030

K VALUE KNOWN TO BE
LESS THAN INDICATED

STORET RETRIEVAL DATE 76/03/30

1817A2
41 18 55.0 085 42 55.0 4
TIPPECANOE RIVER
18 7.5 N WEBSTER
1/JAMES LAKE 051792
E RD BRDG .3 MI UPSTREAM FROM LAKE
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/06/09	12	35	0.378	2.100	0.082	0.007	0.025
73/07/14	07	30	0.105	1.700	0.044	0.006	0.045
73/08/11	10	20	0.320	3.700	0.160	0.007	0.045
73/09/09	13	20	0.180	0.960	0.044	0.007	0.025
73/10/13	10	25	0.560	0.770	0.072	0.010	0.040
73/11/10	12	54	0.036	1.100	0.230	0.005K	0.030
73/12/15	10	10	0.310	0.600	0.048	0.008	0.020
74/01/19	14	35	0.810	0.800	0.148	0.008	0.025
74/02/02	10	40	2.300	0.800	0.055	0.010	0.045
74/02/16	10	05	2.100	1.100	0.063	0.005	0.030
74/03/02	08	40	2.000	1.200	0.085	0.020	0.050
74/03/16	08	50	1.520	1.200	0.025	0.005K	0.035
74/04/13	08	50	1.300	1.100	0.017	0.007	0.007
74/05/19	14	15	0.600	1.200	0.045	0.010	0.035

K VALUE KNOWN TO BE
LESS THAN INDICATED